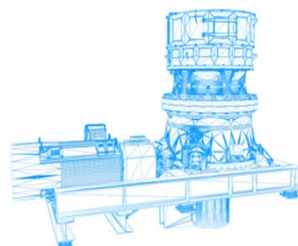
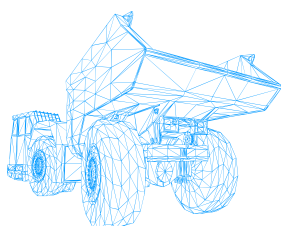
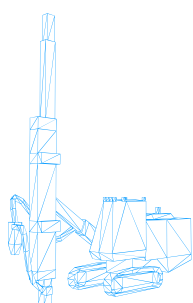


# ECO-EFFICIENCY IN MINING INDUSTRY

## COMMINUTION FOCUS (CRUSHING CONTRIBUTION)

*Hamid-Reza Manouchehri*

*Global Manager, Process Intelligence & Development  
Sandvik Mining & Rock Technology (SMRT)*



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## CHALLENGES IN MINING INDUSTRY

➤ <i>Innovation</i>	➤ <i>Ore complexity, decreasing grade, plus <b>energy and water</b></i>
➤ <i>Productivity improvement</i>	➤ <i>Infrastructure access</i>
➤ <i>Capital dilemma</i>	➤ <i>Balancing talent requirements</i>
➤ <i>Resource nationalism</i>	➤ <i>Sharing the benefits</i>
➤ <i>Price and currency volatility</i>	➤ <i>Cybersecurity</i>

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## TOWARDS ECO-EFFICIENCY

### Eco-Efficiency, what does it mean?

- ✓ **WBCSD (World Business Council for Sustainable Development) introduced Eco-Efficiency in 1992**
- ✓ **It brings the essential ingredients economic and environmental progress, necessary for economic prosperity to increase with more efficient use of resources and lower emission:**

$$\frac{\text{Product or services}}{\text{Environmental influence}}$$

### In general term it is aimed to:

- Reduce material intensity
- Reduce energy intensity
- Reduce dispersion of toxic substances
- Enhance recyclability
- Maximize use of renewables
- Extended product life
- Increased Service intensity



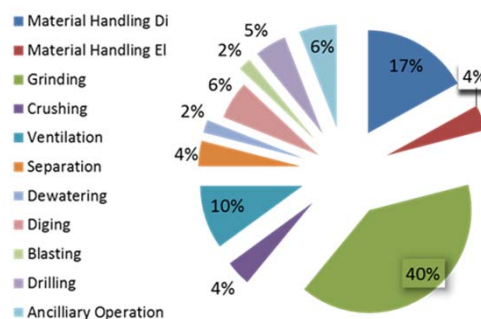
## MINING INDUSTRY - ENERGY

### Why Energy ?

- ✓ **World's Energy Consumption is about  $105 \cdot 10^{12}$  kWh (IEA, BP, 2016)**

✓ **Energy consumption in Mining Industry:  
6-7% of total world's energy: ( $\sim 6,8 \cdot 10^{12}$  kWh)**

✓ **Comminution counts for 2-3%:  
(i.e.,  $\sim 2 \cdot 10^{12}$  kWh)**



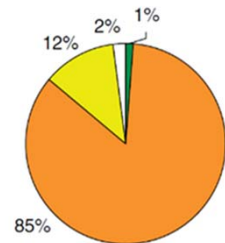
## ECO-EFFICIENCY: WHY COMMINUTION?

- ✓ Comminution energy efficiency is low, in particular in grinding, however, crushers are much more energy efficient than tumbling mills
- ✓ Embodied energy in media production in milling (6-7 MWh/t - 0.5-1 kg/t of media consumption)
- ✓ Adding transportation energy and related cost (e.g., Cerro Verde - 31MW installed for conveying)
- ✓ Water consumption and pollution (future big future challenge):

$$\text{Water Consumption (m}^3\text{/t)} = 167,7 G^{-0.9039}$$

*Consequently, It is logic to push Comminution towards crushing as far as practically possible*

■ Energy Efficiency  
■ Heat Loss  
■ Electromechanical Loss  
□ Other (Kinetics, Noise)



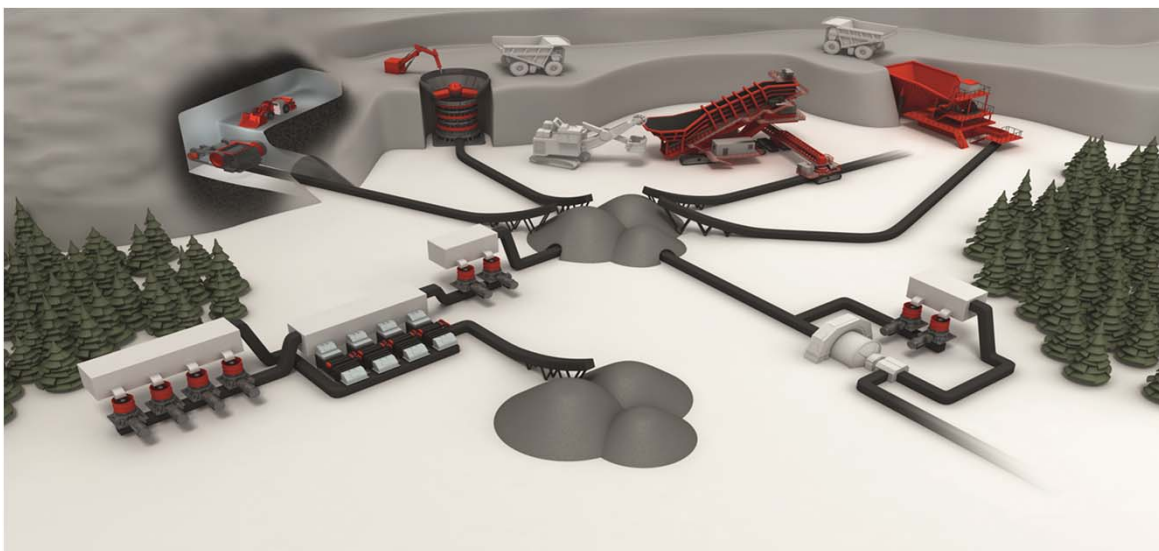
Energy Efficiency in Grinding

Average Energy Efficiency (US Dept. Energy, 2007)  
**Crushing: 50% & Milling: 1%**

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## EFFICIENCY IN MINING & COMMINUTION

- ✓ *Sandvik Mining & Rock Technology (SMRT) – Activities in a glance*



**IK**

# ECO-EFFICIENT COMMINUTION

## ➤ Comprehensive Perspective:

- ✓ *Characterize and optimize feed size and choosing the best comminution circuit accordingly*
- ✓ *Energy for liberation and how to improve it (optimize product size, improve/optimize the methods, liberation at coarser size/grain)*
- ✓ *Waste removal as early as possible (e.g., coarse size screening and sorting)*
- ✓ *More efficient equipment (development and innovation)*
- ✓ *Upgrading the feed to the mill (pre-concentration/grade engineering)*
- ✓ *Measurements and monitoring different process steps from mining till end of processing through effective and fast ways of measurements and evaluations*
- ✓ *Digitalization (data collection, data storage and processing) to serve costumers for improving plant performance*
- ✓ *Introducing wear resistance materials to improve productivity*



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# RDI STRATEGY

## MORE SCIENCE – LESS TRIAL AND ERROR

- *From Trial and Error to Knowledge Driven*
  - Developing and manufacturing more efficient machines and solutions for crushing
  - Modeling and Simulation
  - Measuring and data analytics
  - Scaled experiments and quick verification cycles
  - New tools and methods



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# ECO-EFFICIENT COMMINUTION

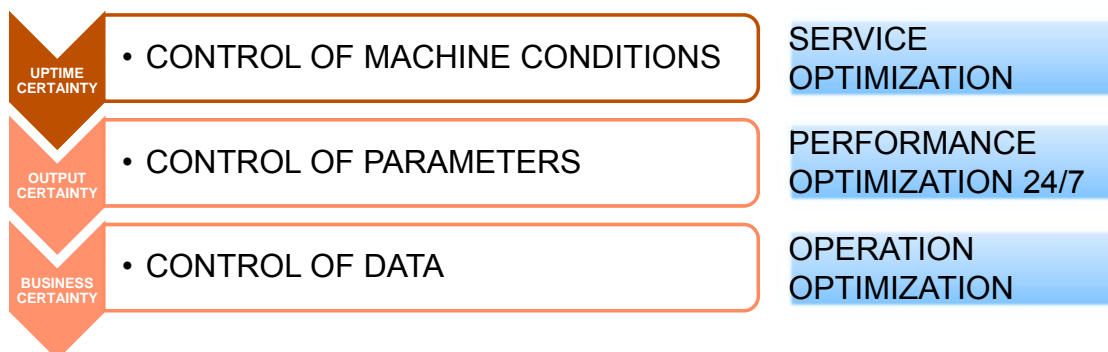
- ✓ *Introducing Prime Crushers (higher energy/force to crushing chamber, e.g., CH860 & CH865)*
- ✓ *Different Crushing Chambers for Quality and/or Quantity improvements (both crushing chamber design and material chosen)*
- ✓ *Wear improvement by choosing wear resistant materials in accordance with application (mineralogy based crushing chamber and screening panel choice)*
- ✓ *Smarter Control System (e.g., ASRi / SanRemo)*
  - *By having automatic control to adjust the crushers about 2.5% to 4% increasing in production for each crusher within two shifts can be expected*
- ✓ *Smart Data Collection and Digitization to Improve Productivity*



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# IMPROVE EFFICIENCY - SANREMO

CERTAINTY IS THE KEY: SANREMO GIVES YOU THE CERTAINTY OF CONTROL



*Good Automation Control of Crusher enables in Reducing Down-Time and Increasing Productivity (2.5-4%)*



# AUTOMATION

## HISTORY



**Marching through technology**  
**> 5000 systems sold around the world!!!**



# AUTOMATION WEB INTERFACE



# CRUSHING CHAMBER SOLUTIONS

## Flexifeed

### ✓ Sandvik has a unique innovative solution to avoid:

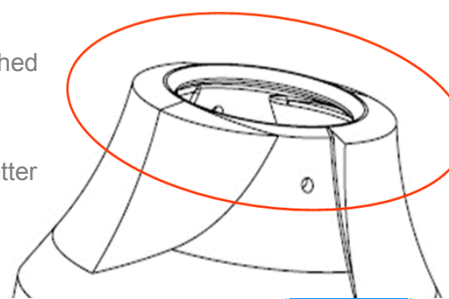
- Problems with occasional stones with top size exceeding the intake crushing chamber
- Unfavorable wear in the lower part of chamber and liner with lifetime shorter than expected

### ✓ Flexifeed feature :

- Flexifeed's intake is smaller in certain parts of the upper mantle circumference which results in a larger fraction of the feed is crushed earlier in the chamber

### ✓ Benefits:

- Extended liner lifetime measured as ton of products/liner by a better utilization of the liner, i.e. a more even wear (+20% in all cases)
- Increased reduction by around 5%
- Maintained production levels throughout the mantle's lifetime



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# CRUSHING CHAMBER SOLUTIONS

## Optiagg

### ✓ Delivers predictable and measurable improvements according to desired output.

*Reduce in fines production or Increase reduction*

### ✓ Optiagg is all the hardware and accessories you need for a complete crushing chamber upgrade including

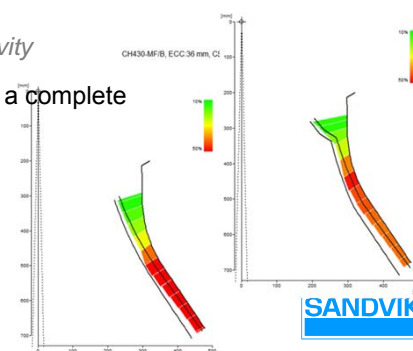
- Including our brand new, high-efficiency mantle design
- Plus a real computer modeling and analysis to improve productivity

### ✓ Optiagg Procedure: is all the hardware and accessories you need for a complete crushing chamber upgrade including

- Sample current crushing product
- Enter results into software
- Optimize crushing chamber selection and improve process
- Install hardware and fine-tune setup
- Verify output result



User Def. MF/CPC k1, ECC:36 mm, CSS:11 mm



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## A COMPLETE PACKAGE

- The smart upgrade for Sandvik's crushing chambers



## FINE CRUSHING – POTENTIAL SAVING

- Conservation in operation cost by improving feed size in mill (gold ore @2.7Mt/y)
- Or increasing mill throughput in accordance with the total installed power

- ✓ Gold grade @ 1.6 ppm, recovery of R=90% , Ore competency @  $W_{ib}=18$  kWh/t and  $A_1=0,6$
- ✓ Gold price @ 1240 US\$/oz, Production cost @ 750 US\$/oz

Feed size (mm)	$E_{total}$ (kWh/t)	Energy reduction from base case	Media (kg/t)	Liner (kg/t)	Operation cost saving (MUS\$)	Gaining by increase throughput MUS\$
15	20,97	0	2,77	0,21	0	0
12	20,17	3,8	1,71	0,131	0,66	2,166
10	20,13	4,0	1,62	0,125	0,71	2,477
6	18,30	12,74	1,54	0,119	2,61	7,715
4	16,40	21,8	1,45	0,112	3,84	13,36

- Note: steel media @1500 US\$/t , liner @1200 US\$/t, energy @ 0,1 US\$/kW-h





## CONCLUSION

We believe that energy conservation up to 20% can be achieved by available technologies. Sandvik design and develop crushers, as well as wear materials, soft-wears and instrumentation to control and improve comminution:

- *Instrumentation, Measurements, Control and Process Optimization*
- *Classification and Size Control (efficient screening is paramount important)*
- *Energy Efficient Comminution (towards effective fine crushing/comminution)*
- *Materials Engineering and development for crushers (towards choice of material by application in corporation mineralogy and ore competency)*
- *Expert Team(s) to service and offer and develop flow-sheets, solution, and consultancy to the Mining Industry*



## EFFICIENCY IN MINING & COMMINUTION



**Sandvik Mining & Rock Technology (SMRT)**

**Comprehensive Perspective for Mining and Processing to improve efficiency**



## CONCLUSION - FUTURE STRATEGY

- ✓ **Sandvik Mining & Rock Technology (SMRT) –**
- *Being innovative in providing solutions by considering mining and process as one scenario*
- *Developing energy efficient and reliable machines equipped with sophisticated soft-wears for measurements, control and process optimization (bridge the gap in comminution)*
- *Data collections and digitalization towards complete automation and strategies in optimal use of the information (cybersecurity, easy to access and improving personnel knowledge)*
- *Materials engineering and development in order to track product performance through its life cycle (life cycle management for productivity)*
- *Building expertise at different levels for design, manufacturing, training, educating, and consultancy – Having competent talents for future development and skill storage*

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## CONCLUSION - OBSTACLES

- *Sustainability in Mining is a paradox, we need to be smart and innovative*
- *Cycle times between knowledge generation and implementation are often long*
- *Scaling up the new developed technologies is rather difficult*
- *It is difficult to justify changes and incorporate the new technologies in practices (more fundamental the change the longer is the time for implementation)*
- *Mining Industry is knowledge-based with a short term focus on staying viable, but with long timeframes for implementation of new technologies (e.g., 10-15 years)*
- *Investment in R&D (more than current rate of about 1% for major companies)*
- *Fluctuations in global economy influencing long term vision and investment*
- *R&D infrastructure (change needs to embrace a greater part of external research)*

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